SOME PROBLEMS OF MODERN METEOROLOGY

[Review]

Beginning with July 1930, a series of articles, each giving a critical inventory of our knowledge of some special branch of meteorology, has been running in the *Quarterly Journal of the Royal Meteorological Society*. This series, just completed, has been assembled, with a few notes that bring the articles to date, in book form, octavo, 170 pages, and made available at moderate cost. The subjects discussed and their importance are best indicated, perhaps, by the table of contents, herewith, and the introduction, next quoted, by D. Brunt:

When in 1930 the Council of the Royal Meteorological Society invited me to take over the duties of editor of the society's publications, it occurred to me that a series of articles dealing with the problems of modern meteorology would serve a useful purpose in the present stage of the development of the science. The idea was suggested by my recollection of an excellent series of articles on the problems of astronomy which was published in the *Observatory* some 20 years ago, and there seemed to be every reason to suppose that a similar series of articles dealing with meteorological problems would be of interest to readers of the *Quarterly Journal*. The aim of these articles, which are now reproduced collectively in this volume, was to give summaries of certain aspects of meteorology in the form of critical discussions of existing theories, rather than to advocate new theories. To some extent the project was regarded as an attempt to take stock of our present knowledge, to find how much of modern meteorological theory is generally agreed upon, or failing this, to attain some agreement as to what we do not know. The 16 papers which follow do not by any means exhaust the problems of modern meteorology; but many of the problems of the atmosphere are unfortunately not sufficiently clear even to permit of definite formulation.

A tthe present time it appears to be particularly desirable to take stock of our knowledge of atmospheric processes. The acceleration in the rate of publication of papers on the subject has been so great in the last few years that it is difficult to visualize what has been the net gain since the birth of scientific meteorology. The main difficulty to be faced in planning such a stock-taking, indeed the main difficulty in planning any coherent treatment of meteorology, whether in the form of a textbook or otherwise, is the absence of a central connecting thread in the form of a clear-cut theory of the circulation of the atmosphere. In the absence of such a central thread it is not possible to decide finally what is essential, and what is of only temporary interest. It is hoped that the series of articles now reprinted will be of interest, not only to the meteorologist, but also to others who desire to know something of the present state of meteorology.

Advantage was taken of the opportunity offered by the reprinting of the series to add brief notes supplementing the original articles where that seemed desirable, and the author was readily accessible. These additional notes are given at the end of the volume. They are mainly brief references to additional papers which were not mentioned in the original articles, and it is unfortunately not possible to say that any of the problems have been solved since they were formulated.

Meteorology is essentially an observational science. Since it is not possible to control atmospheric conditions, all that the meteorologist can do is to observe all the salient factors in the greatest possible detail. But difficulties arise when any attempt is made to define what are the salient factors. We may adopt as a truism the maxim that "the same causes will always produce the same effects", but in meteorology we can only adopt with reservations the maxim that "like causes will produce like effects." The latter maxim is only true when small variations in the initial conditions produce only small variations in the final state of the system. Clerk Maxwell pointed out in "Matter and Motion" that while this condition is satisfied in a great many physical phenomena, there are other cases in which a small variation in the initial conditions may produce a very great change in the final state of the system, much as the displacement of the points on a railway may cause a train to run into another, instead of keeping to its proper course. At the end of the paragraph in which Maxwell discussed these principles, Larmor appended a note that "the observable regularities of nature belong to statistical molecular phenomena which have settled down to permanent stable conditions. Insofar as the weather may be due to an unlimited assemblage of local instabilities, it may not be amenable to a finite scheme of law at all."

To apply these considerations to the domain of meteorology leads at once to two questions: (1) If the observed surface distributions of pressure, temperature and humidity, as shown on the synoptic chart, are similar on two occasions, to what extent is the apparent similarity effectively modified by differences in the upper air? (2) If the conditions both in the upper air and at the ground are in the main similar on two occasions, will the small differences between the two occasions lead to small or large differences in the final developments?

There is little doubt that the answer to the first question is that conditions represented by similar synoptic charts of surface pressure may, and often do, develop into widely different conditions, so that the similarity of today's chart to some earlier one is not a safe guide for the forecaster. The cause of the dissimilarity in the later development in two such cases may possibly be dissimilarity of conditions in the upper air. Or it may be that the idea of similarity is based on a comparison of conditions over too small an area, and that a comparison over a wider area, notably if taken over a whole hemisphere, would show dissimilarities in the surrounding field. It would appear possible to investigate this question when the daily charts of the northern hemisphere, which are to be published for the period of the polar year, become available.

The answer to the second question cannot yet be given, since a sufficient number of observations in the upper air is never available. It is therefore never possible to state with complete confidence what are the conditions in the upper air on any one day, still less to compare these conditions on one day with those on another day. Upper air observations are only available in fair weather. In stormy weather they are usually very sparse, and it is not usually possible to state at all clearly the exact nature of the distribution of temperature or of wind in the upper air above a depression. For these reasons it is not possible to state how far initial small differences can lead to different conditions in the later development of two situations which initially show quite a marked resemblance.

The answer to the first question stated above is of far more than academic interest to the meteorologist. If indeed it were true that small initial differences can lead to great differences in the later development, then it is probable that no improvement in forecasting is to be looked for, beyond the slight improvements which will follow from the increase in the amount of information available, and increased rapidity of transmission, since it is not probable that a trigger action could be foretold with accuracy. If it may be assumed that small differences in initial conditions lead to only small differences in the final development, then it should be possible to develop a true science of forecasting, which can hope to trace out the course of the weather for more than a day in advance. At present, few British forecasters would care to issue forecasts for more than a day in advance as a daily routine. It is not, however, clear in what direction a further advance is to be looked for. The one outstanding new idea of the last 20 years is that associated in the minds of most meteorologists with the "polar front." The greatest achievement of this idea is the establishment of the fact that a cyclonic depression has a life cycle, not only in its lower levels, but also in the cirrus levels. The time is surely ripe for some new idea to be brought forward, and many young meteorologists are eagerly looking for a new method which may help to elucidate some of the puzzling features of the physics of the atmosphere. But it is not clear where the new idea is to come from. At the end of 1918

many meteorologists looked to an increase in the amount of upper-air data available, to help to solve their riddles. There has unquestionably been a considerable increase in the amount of upper-air data available every day, but it is doubtful whether they have proved as useful as was anticipated some 16 years ago. In practical forecasting the use which can be made of upper-air data is relatively small. At times an observation of temperature in the upper air may facilitate the forecasting of thunderstorms or of rainfall, but there are many days when the practical use made of the upper-air data is only slight. The present writer is well aware that some will differ from this view, but that others will undoubtedly agree. It may be that the advance for which we are looking will come from the application of thermodynamical reasoning to upper-air data, along the lines laid down by Shaw, Normand, Rossby, and Stuve, but at the moment it is not clear how far the methods of these workers can be of real use in day-to-day synoptic analysis.

There is a well-established fact which accounts for the difficulty of making fuller use of upper-air data, namely that such atmospheric features as cyclonic depressions, wedges of high pressure, and anticyclones, which travel from west to east, manifest themselves at low levels earlier than at high levels, to an observer at a fixed place.

One writer in a recent number of the *Quarterly Journal* expressed his belief that no obvious factor or line of attack could have escaped notice, in view of the large number of able young men now actively engaged in meteorological work. But it will be recalled that the ideas underlying the "polar front" methods were only very thinly disguised in Shaw and Lempfert's "Life-History of Surface Air Currents," and yet they did not attain full development until many years had elapsed. Many much older papers than that of Shaw and Lempfert may contain ideas which could now be elaborated with great profit in the light of our present knowledge of the physics of the atmosphere.

But whatever the future may bring, it is hoped that the statements of the present position with regard to certain aspects of meteorology which are contained in the series here reproduced may help to advance the science by clearing the ground of some obscurity, and helping to develop in the reader the right attitude of healthy sceptism.

BIBLIOGRAPHY

C. FITZHUGH TALMAN, *in charge of Library*

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